No induction

(12) UK Patent Application (19) GB (11) 2 244 804 (13) A

(43) Date of A publication 11.12.1991

(21) Application No 9112094.9

(22) Date of filing 05.06.1991

(30) Priority data
(31) 9012845 (32) 08.06.1990 (33) GB

(71) Applicants
Christopher Charles Ree
27 Cotefield Drive, Leighton Buzzard, Bedfordshire, LU7 8BQ, United Kingdom

Mahill Holdings Limited

(Incorporated in the United Kingdom)

Unit J, Mill Race Lane, Stourbridge Trading Estate, Stourbridge, West Midlands, DY8 1YL, United Kingdom

(72) Inventor
Christopher Charles Ree

(74) Agent and/or Address for Service
Marks & Clerk
Alpha Tower, Suffolk Street Queensway, Birmingham, B1 1TT, United Kingdom

(51) INT CL[5]
F24F 13/04, F04F 5/16 5/46, F24F 3/00 // F24F 1/01

(52) UK CL (Edition K)
F4V VFBJ VF403 VGAA VG212 VG220 VG225 VG228 VG229 VG241 VG242 V159 V302 V305 V307 F1E EAA EEA

(56) Documents cited
GB 0950323 A EP 0326950 A2 US 4913036 A
US 4858519 A US 4657178 A

(58) Field of search
UK CL (Edition K) F1E EAA EEA, F4V VFBJ VFC VFX VGAA VGAB VGBR VGBS VGBV
INT CL[5] F04F 5/14 5/16 5/46, F24F 1/01 13/02 13/04 13/06
Online databases: W.P.I.

(54) Air conditioning system and method; jet pumps

(57) An air conditioning system includes an air handling unit (50) for supplying treated primary air through ductwork (48) to a multiplicity of air mixing devices (49), each of which comprises an adjustable convergent nozzle device (12) (Fig. 2) having its outlet upstream of an inlet end of a duct (24) so that discharge of the primary air from the narrowed nozzle outlet entrains air from around the nozzle device, the resultant mixture forming secondary air which is discharged from the duct into a space to be conditioned. The unit (50) has means for heating or cooling (45, 44) the primary air, which may itself be a mixture of fresh air and recirculated air from the conditioned space, whilst the entrained air may also be treated e.g. by heat exchangers (35) prior to its mixing with the primary air. Duct (24) is extended by mesh (26) which surrounds nozzle (12). Duct (24) has a sound attenuating lining (32) and insulating cover (31) and may include an adjustable discharge head (27) with dampers (29).

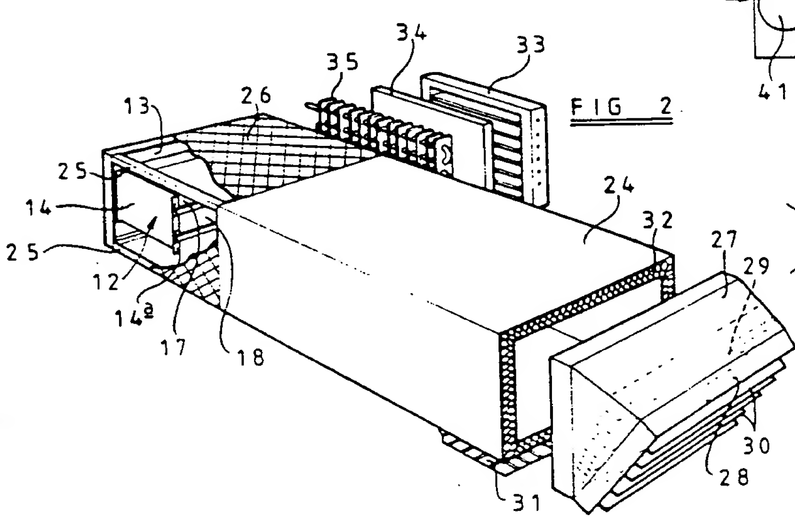

FIG 2

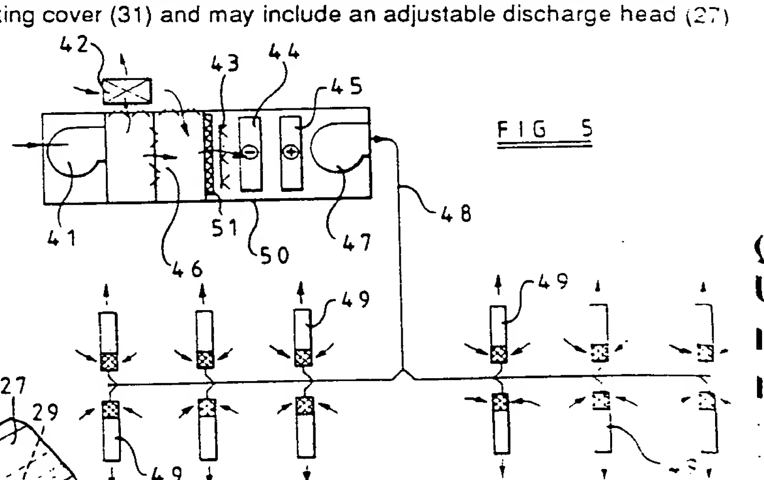

FIG 5

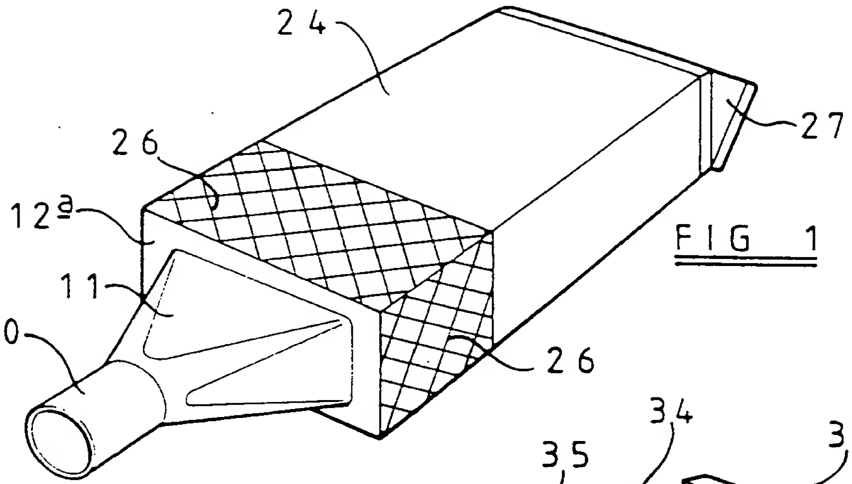

FIG 1

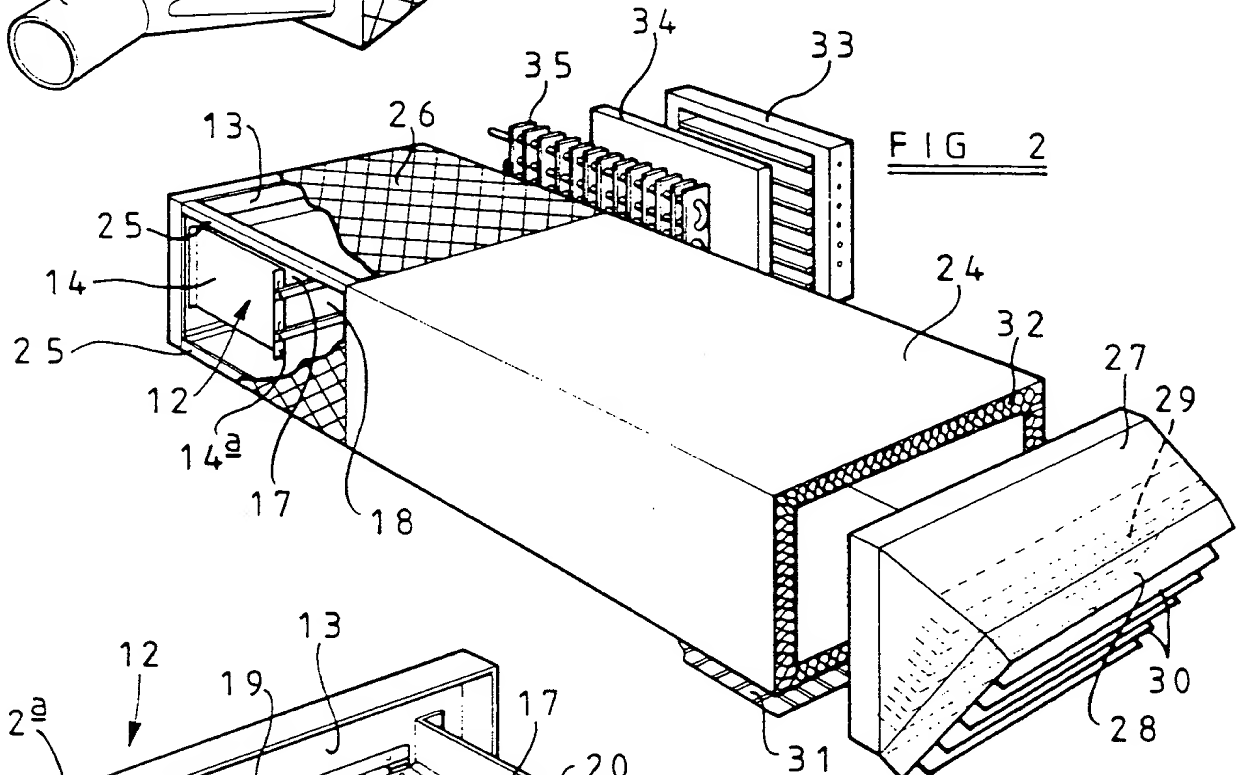

FIG 2

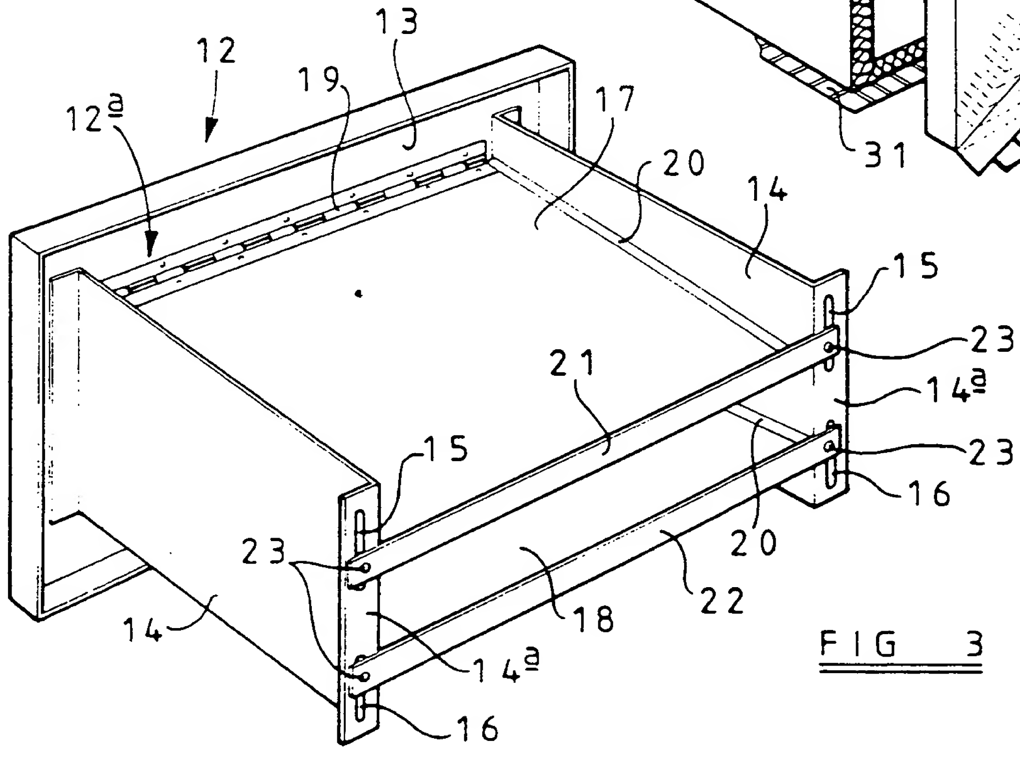

FIG 3

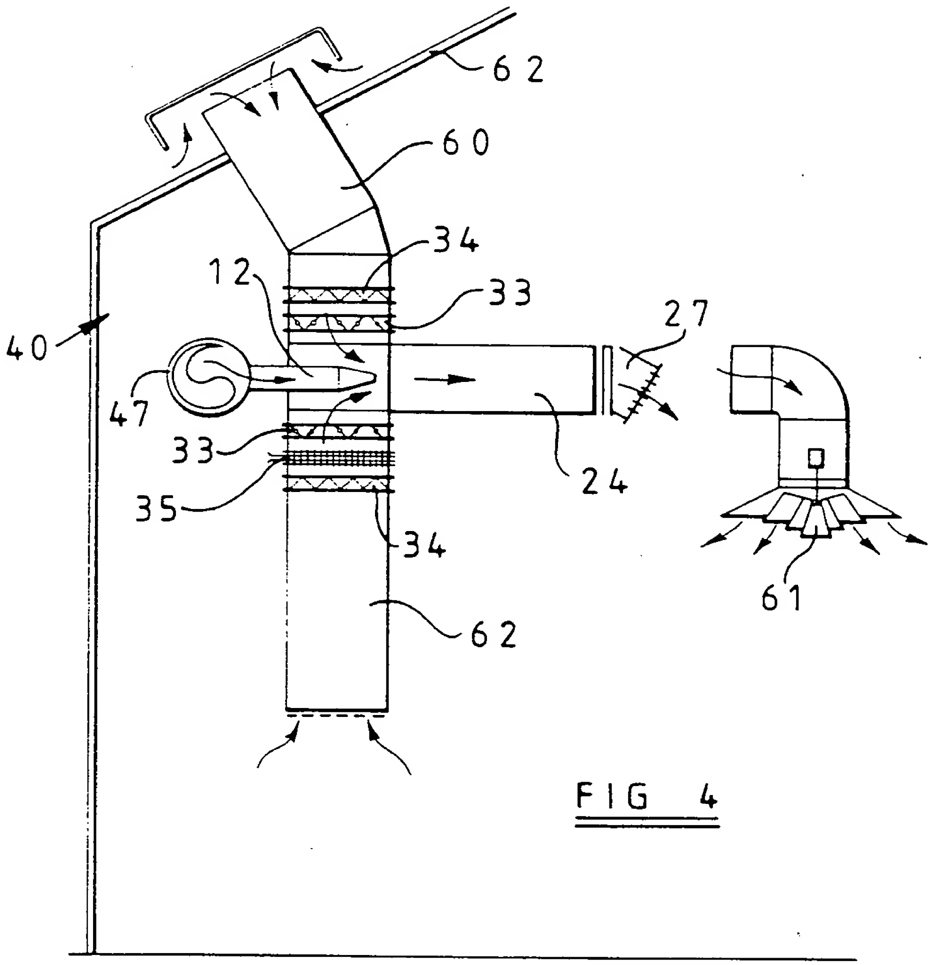
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FIG 4

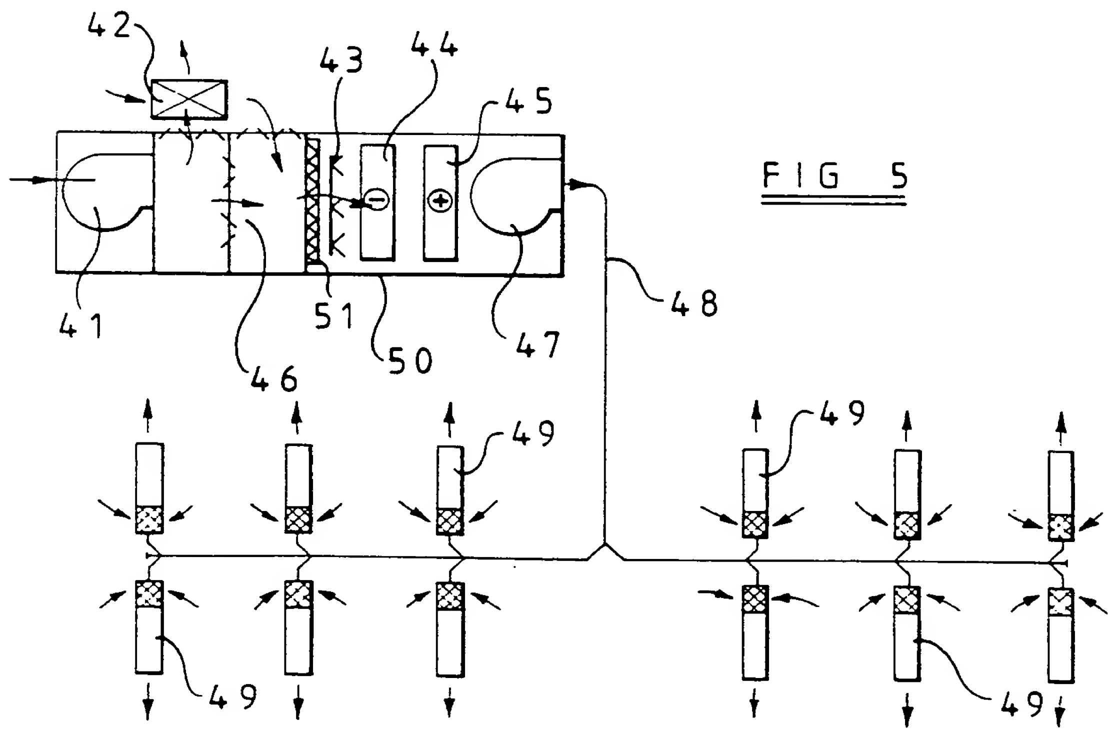
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FIG 5

AIR CONDITIONING SYSTEM AND METHOD

This invention relates to an air conditioning system, particularly, though not exclusively, for use in the heating/cooling and/or ventilating of buildings, particularly warehouses, offices, factories or the like, where air is delivered through a ductwork system to air mixing devices. The invention also relates to an air conditioning method, particularly using said air mixing devices.

An object of the invention is to provide an improved air conditioning system and air conditioning method.

According to the present invention an air conditioning system comprises an air mixing device having a duct with respective inlet and outlet ends, and a convergent nozzle device disposed outside of the duct and having an outlet end thereof spaced upstream of the duct inlet end, so that, in use, primary air supplied through said nozzle device discharges from the nozzle device outlet end and entrains air therearound, the resultant mixture, forming secondary air, passing along said duct from its inlet end to its outlet end where there is discharge of said secondary air.

According to another aspect of the present invention a method of air conditioning comprises supplying primary air to an air mixing device having a convergent nozzle device and a duct, the duct having respective inlet and outlet ends and the nozzle device being disposed outside of the duct with an outlet end thereof spaced upstream of the duct inlet end, said primary air discharging from the outlet end of the nozzle device and entraining air therearound, the resultant mixture, forming secondary air, passing along

said duct from its inlet end to its outlet end, where said secondary air is discharged.

The invention will now be described, by way of example, with reference to the accompanying drawings, in which:

Figure 1 is a perspective view of an air mixing device of an conditioning system of the invention,

Figure 2 is an enlarged, partly cut-away more detailed view of part of the device of Figure 1, with possible additional features shown,

Figure 3 is an enlarged, detailed view of a nozzle of the device.

Figure 4 shows an example of an air mixing device incorporated in an air conditioning system in a building, and

Figure 5 schematically shows an air conditioning system of the invention.

The air conditioning system of the invention is primarily intended for use in industrial buildings, where primary air is supplied under high pressure along small diameter ducting to a plurality of air mixing devices, each having an outlet nozzle.

In Figure 1 shows a mixing device of an air conditioning system of the invention, the device having an entry section for 'primary' ductwork air, the entry section being formed of a short circular-section duct 10 integral with a transition piece 11, the internal and external cross-section of which changes from circular to rectangular along its length.

At its rectangular outlet end, the transition piece 11 is connected to a front face of a rectangular backplate 12a of a nozzle 12 of the mixing device, the backplate having a rectangular aperture therethrough shaped to correspond to the connected rectangular end of the transition piece, but slightly smaller than it so that a seal is formed around it.

Fixedly secured to the rear face 13 of the backplate are two vertical side plates 14 which extend normally away from the face 13 slightly outside the shorter sides of the aperture respectively. Each side plate has its free end bent outwardly through 90° to form a flange 14a and each flange 14a has vertically aligned upper and lower elongate slots 15, 16 respectively therein. Between the side plates, at the top and bottom of the aperture in the backplate, a pair of adjustable top and bottom plates 17, 18 respectively are connected by hinges 19 to the rear face 13. The hinges are sealed to the rear face 13 and respective rubber edge seals 20 are provided at the side edges of both plates 17, 18 to seal against respective inner surface of the side plates 14.

After their free ends, the top and bottom plates 17, 18 are turned through 90° away from each other, and the respective outwardly turned flanges 21, 22 so formed have respective pairs of holes at their extended opposite ends for reception of bolts 23. The bolts pass through respective soft rubber washers between the flanges 21, 22 and the flanges 14a, and then pass through the slots 15, 16 as shown in Figure 3, to carry respective nuts (not shown). Thus, in use, the nuts can be loosened to allow the top and bottom plates to be adjusted up or down to vary the size of the nozzle, the nuts then being tightened to provide a rigid assembly. As will be described, primary air from the circular ductwork of a building passes through the entry section and then into

the nozzle through its aperture. Variation of the nozzle size alters the volume and velocity of the primary air passing therethrough. This adjustability of the nozzle size is a particularly advantageous feature of the air mixing device.

The primary air discharging from the nozzle expands, its volume increasing as it diverges and induces/entrains air from the surrounding space, as will be described.

The backplate of the nozzle is rigidly connected to a elongated, rectangular section of ducting 24 by four corner angles 25, the outlet of the nozzle being spaced some way upstream of the inlet of the ducting 24, as shown in Figure 2. The space between the corner angles 25 from the nozzle backplate to the ducting inlet is covered on all four sides by a metallic, open mesh 26 having a high free area. The 'mesh' can take any suitable alternative form from that shown and includes within its scope any air permeable 'cover' over and around the nozzle end.

The ducting 24 has at its outlet end a discharge head 27 which can be adjustable to vary the angle of discharge from the ducting 24, e.g. to distribute air to ground level. The discharge head has an outlet grille 28 at its outlet end and it can also have airflow control blades 29 disposed between its ends. The blades 29 can be horizontally adjustable. Similarly the outlet grille can have adjustable horizontal or vertical blades 30.

As shown in Figure 2, insulation material 31, with or without a moisture barrier, can be fitted to the outside of the ducting 24, preferably on all outer faces. Similarly sound attenuation material 32 can be fitted to the inside of the ducting, preferably on all inner faces.

As mentioned, the divergence of the primary air as it discharges from the nozzle entrains air from the surrounding space. As the air stream expands its volume and velocity change.

The air in the surrounding space which is entrained with the expanding primary air flows into the mixing device through the mesh 26. This air can be treated prior to its mixing and Figure 2 shows various treatment devices to be fitted at or adjacent the outside of the mesh. Numeral 33 indicates an adjustable damper to control the volume of air supplied. The damper can be manually or motor operated. Numeral 34 indicates an air filter for filtering the induced airstream and numeral 35 indicates a heating or cooling coil for altering the temperature of the induced air. These treatment devices can be in any order relative to the induced air flow.

Any combination of the treatment devices can be used or only one can be used. An opening can be provided in the mesh for fitting the or each device, or the or each device can be fitted with the mesh remaining. This treatment facility is another particularly advantageous feature of the air mixing device.

Once the treated or untreated air from the surrounding space has been entrained with the primary airflow, the mixed or secondary air is limited in its expansion as it discharges into the rectangular section of ducting 24. To provide treatment of the secondary air, a facility has been incorporated to streamline the air for even airflow over the ducting section. The dimensions of the containment ducting 24 and the nozzle size are calculated to provide the required supply air stream for discharge into the building containing the air conditioning system.

The secondary air discharges through the discharge head 27 at the required angle by adjustment of the head 27, the width of which will vary with throw and air volume.

As will be appreciated, various different sizes of nozzle and/or ducting can be used, to suit the volume of secondary air required to discharge into any particular area of the warehouse, office, factory or the like. The induction box with the discharge grille attached would normally be at high level in the building, discharging the air to ground level. For other applications the assembly could be located in a ceiling or wall or even discharge at low level. Instead of a rectangular aperture, a circular aperture could be provided in the nozzle backplate.

Figure 4 schematically shows a primary air distribution duct 47 supplying treated primary air to the nozzle 12 of an air mixing device fitted high in a building 40. For convenience the nozzle is shown in simple, non-adjustable form, but this would in practice be as in Figures 2 and 3, with mesh around it and with its outlet upstream of the ducting 24 which has a discharge head 27.

If the air to be induced into the mixing device is to be fresh air, a fresh air intake duct 60 can be located in the roof 62 or a wall of the building, the fresh air preferably passing through an air filter 34, adjustable damper 33 and possibly a heating or cooling coil, such as coil 35. The fresh air around the nozzle device outlet end is entrained as with the surrounding space air described.

When the air conditioning system has high level mixing devices and is providing mechanical cooling through the use of a cooling coil 44 in a primary air

handling unit 50 (Figure 5), then the system incorporates an intake duct 62 for induction of mixing air from a low level in the building 40. The duct 62 can incorporate any one of air filter 34, coil 35 and damper 33 alone or in combination. The duct 62 could replace intake duct 60 together with its damper 33 and filter 34 or could be used with it as shown.

Instead of the discharge head 27, a supply diffuser 61 can be fitted at the end of the ducting 24, for both heating and cooling applications. This diffuser incorporates a device which changes the performance of the diffuser for heating or cooling. Preferably said device is a fluid which expands or contracts to initiate operation of an actuating rod which raises or lowers the diffuser blades to change the diffuser performance. A different temperature sensitive means could be used.

When the air mixing device is used in a system for heating, the airflow from its discharge end requires greater penetration to ground level to overcome the rising effect of heated air, as compared with that required for cooling. The fitting of the diffuser with a temperature sensing device,which changes the discharge air flow performance,maintains the required comfort conditions for both heating and cooling.

Figure 5 shows a complete air conditioning system layout for heating or cooling a space, the system having said primary air handling unit 50 which can incorporate one or both different heating or cooling sources 45, 44 respectively. To transfer the conditioned primary air from the unit 50 is circular section ductwork 48, this distributing the primary air to the mixing devices of Figures 1 to 3, denoted here by the numeral 49. At the devices 49 the primary air is mixed with induced secondary air from the space where the devices 49 are

fitted, the resultant mixture being discharged into the conditioned space.

The heating and cooling sources are indirect in nature, so that the medium which conditions the primary air does not mix with it, and heat transfer to or from the primary air occurs by way of it passing across the containment for the heating or cooling medium. Accordingly any poisonous gases and/or solid particles resulting from combustion to provide the heating source are not discharged into the space, leading to improved air quality therein.

Various sources for heating or cooling can be used. Examples are: indirect gas or oil fired heating, hot water coils, steam coils, thermal oil coils, chilled water coils, coils containing refrigerant and cross flow air to air heat exchangers 42.

The primary air handling unit has a mixing box 46 that may or may not be in air flow communication with heat exchanger 42 and/or a fan 41 to extract and/or recycle air from the space or elsewhere. The air entering the treatment part of the unit 50 may thus be 100% fresh air or 100% recirculated air or any proportion of fresh and recirculated air. From the mixing box 46 the primary air can be filtered at 51 and humidified or de-humidified at 43/44. After passing through the treatment part, the heated or cooled primary air is distributed along the ductwork 48 by a primary fan or blower 47. The spiral wound ductwork 48 may or may not be insulated, this being dependent upon the air condition within the ductwork and the conditioned space.

The primary air temperature, as a result of heating whilst passing through the unit 50, will preferably be in the range of 30°C to 100°C.

For cooling, the primary air will preferably be supplied from the unit 50 with a temperature with a temperature in the range of 3°C to 15°C.

The air conditioning system has a control panel (not shown) to maintain the desired air conditions within the space by way of sensors or thermostats.

The adjustability of the nozzle of the air mixing device allows its area to be changed relative to the fixed area of the ducting 24. Thus the induction effect can be modified by changing the relationship between the two areas, the spacing of the nozzle outlet upstream of the ducting inlet allowing mixing of the primary and secondary air prior to entering the ducting. The induction effect can thus be modified by this adjustability of the nozzle, in contrast to the results obtainable from a fixed area nozzle. The adjustability allows for improved setting of induction rates within a building for altering airflow conditions to meet design requirements and modifying airflow conditions that may be required by change of building use.

When the air conditioning system is used for cooling, it is more efficient to induce cool air from a low level in the building than to induce warmer air at high level therein, for example by use of duct 62. This provides a cooler, lower zone in the building where cooling is required. A thermostat can be located at low level in the building, and if high level warm air were to be induced and the mixture discharged to low level, the thermostat would call for additional cooling.

CLAIMS

1. An air conditioning system comprising an air mixing device having a duct with respective inlet and outlet ends, and a convergent nozzle device disposed outside of the duct and having an outlet end thereof spaced upstream of the duct inlet end, so that, in use, primary air supplied through said nozzle device discharges from the nozzle device outlet end and entrains air therearound, the resultant mixture, forming secondary air, passing along said duct from its inlet end to its outlet end where there is discharge of said secondary air.

2. A system as claimed in Claim 1, wherein mesh having generally the same cross-sectional shape as the duct extends upstream from said duct inlet to a position beyond said outlet end of the nozzle device, so that, in use, air from the surrounding space passes through the mesh to be entrained by the primary air discharging from the nozzle device outlet end and form said secondary air.

3. A system as claimed in Claim 2, wherein the mesh extends from the inlet end of the duct to an inlet end of the nozzle device.

4. A system as claimed in any one of Claim 1 to 3, wherein the degree of convergence of the primary air effected, in use, by the nozzle device is variable.

5. A system as claimed in Claim 4, wherein the degree of convergence is variable by means of adjustable nozzle plates.

6. A system as claimed in any one of the preceding claims, wherein a discharge head is provided at the outlet end of the duct.

7. A system as claimed in Claim 6, wherein the discharge head is adjustable to change the direction of secondary air discharge from said outlet end of the duct.

8. A system as claimed in Claim 6 or Claim 7, wherein the discharge head incorporates airflow control blades between the ends.

9. A system as claimed in any one of Claims 6 to 8, wherein the discharge head has an outlet grille at its outlet end.

10. A system as claimed in Claim 9, wherein the outlet grille has airflow control blades.

11. A system as claimed in any one of Claims 1 to 5, wherein a supply diffuser is provided at the outlet end of the duct, the diffuser having temperature sensitive means to cause movement of airflow blades of the diffuser in response to heating or cooling.

12. A system as claimed in any one of the preceding claims, wherein the air from a space surrounding the mixing device is treated prior to its entrainment by the primary air by passage through at least one treatment device.

13. A system as claimed in Claim 12, wherein the air from the surrounding space passes, in use, through one or more of an adjustable damper, an air filter and a heating or cooling coil, each of which constitutes a treatment device.

14. A system as claimed in any one of the preceding claims, wherein insulation material is fitted to the outside of the duct.

15. A system as claimed in any one of the preceding claims, wherein sound attenuation material is fitted to the inside of the duct.

16. A system as claimed in any one of the preceding claims, wherein the nozzle device has an entry section comprising a circular duct leading to a transition piece which changes in cross-section from circular to rectangular and which is fitted at its rectangular end to a rectangular inlet end of the nozzle device.

17. A system as claimed in any one of the preceding claims, including a fresh air intake duct having an inlet intended to be disposed outside of a space to be conditioned, in use, and an outlet arranged to direct said fresh air to a position for entrainment by said air discharged from said nozzle device outlet end.

18. A system as claimed in any one of the preceding claims, including an intake duct for feeding air, in use, from a low level in a space to be conditioned to a position for entrainment by said air discharged from said nozzle device outlet end.

19. A system as claimed in any one of the preceding claims, including an air handling unit having one or both of heating and cooling devices selectively to treat primary air.

20. A system as claimed in Claim 19, wherein the heating device or the cooling device is indirect.

21. A system as claimed in Claim 19 or Claim 20, wherein the air handling unit has a mixing chamber for supplying 100% fresh air, recirculated air or a mixture of fresh air and recirculated air to be heated or cooled.

22. A system as claimed in any one of Claims 19 to 21, wherein the air handling unit has means for humidifying/ de-humidifying primary air.

23. A method of air conditioning comprising supplying primary air to an air mixing device having a convergent nozzle device and a duct, the duct having respective inlet and outlet ends and the nozzle device being disposed outside of the duct with an outlet end thereof spaced upstream of the duct inlet end, said primary air discharging from the outlet end of the nozzle device and entraining air therearound, the resultant mixture, forming secondary air, passing along said duct from its inlet end to its outlet end, where said secondary air is discharged.

24. A method as claimed in Claim 23, wherein the mixing device is fitted at a high level in a space to be conditioned, mechanically cooled primary air is supplied to the nozzle device of the mixing device and air from a low level in the space is drawn into entrainment with the primary air through an intake duct.

25. A method as claimed in Claim 23 or Claim 24, wherein fresh air from outside a space to be conditioned is drawn into entrainment with said primary air through a fresh air intake duct.

26. A method as claimed in any one of Claims 23 to 25, wherein primary air is supplied to said air mixing device from an air handling unit where the primary air is heated or cooled.

27. A method as claimed in Claim 26, wherein the primary air is humidified/de-humidified in said air handling unit.

28. A method as claimed in Claim 26 or Claim 27, wherein the primary air is 100% fresh air or 100% recirculated air.

29. A method as claimed in Claim 26 or Claim 27, wherein the primary air is formed by mixing fresh air and recirculated air in a mixing chamber of the air handling unit.

30. A method as claimed in any one of Claims 23 to 29, wherein the primary air is heated to a temperature of between 30°C and 100°C before being supplied to said air mixing device.

31. A method as claimed in any one of Claims 23 to 30, wherein the primary air is cooled to a temperature of between 3°C and 15°C before being supplied to said air mixing device.

32. An air conditioning system substantially as hereinbefore described, with reference to, and as shown in Figures 1 to 5.

33. A method of air conditioning substantially as hereinbefore described, with reference to, and as shown in Figures 4 and 5.

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